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(54) **SHEET BLANK FORMING METHOD AND DEVICE FOR THE IMPLEMENTATION THEREOF**

(57) The invention relates to machine building, namely to metal forming, and can be used in dies of sheet stamping to control local forces under a specified algorithm.

The suggested technical object is aimed at increasing the technological capabilities of the sheet stamping process and accuracy of manufactured parts, as well as at increasing the possibility of its use on universal equipment.

This task is solved by installation of a differentiated hold-down device into the die; the device ensures the following during workpiece forming: adjustment of metal flow and movement from the periphery into the deformation zone by way of local force control. The differentiated hold-down device has a hold-down made of sectors that are fastened on a plate, and each hold-down sector is equipped with a hydraulic device for force transfer under a specified algorithm. The differentiated hold-down device comprises a hydraulic device for force transfer under a specified algorithm, and, preferably, comprises a housing, a stem with a piston, wherein the housing comprises rings with an internal surface of variable cross-section, which together with the piston's peripheral surface form a clearance that may change during piston movement in relation to the housing. Additionally, the differentiated hold-down device may comprise a hydraulic device for force transfer under a specified algorithm, which consists of a housing, a stem with piston, the stem is hollow and has radial holes, while the piston is provided with a movable ring configured to close the piston hole, the housing comprises an axle of variable cross-section, one end whereof is made in the form of a piston placed in the stem cavity, wherein the movable ring together with the axle of variable cross-section form a clearance changing during movement of the hollow stem with the piston and ring in relation to the axle.

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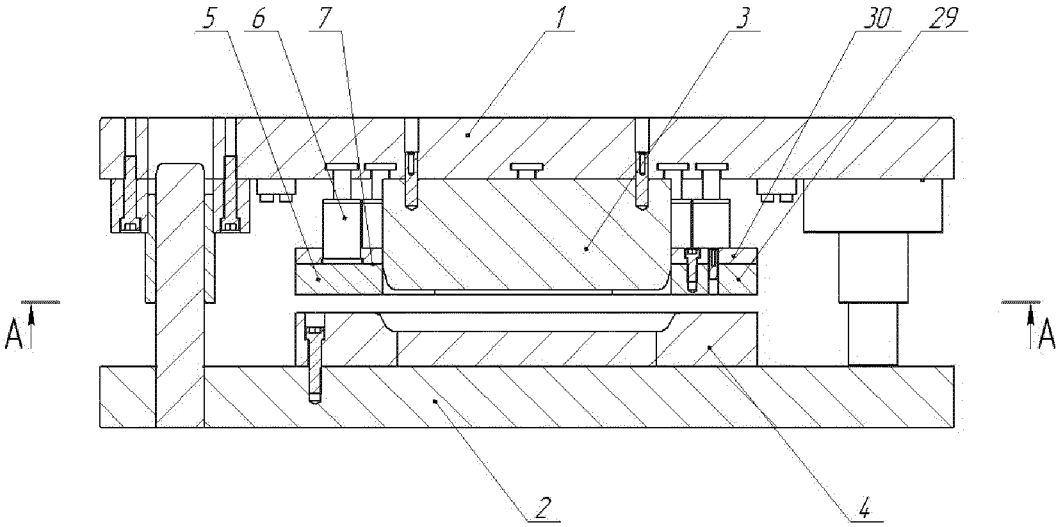


Fig.1

Description

[0001] The invention relates to machine building, namely to metal forming, and can be used in dies of sheet stamping to control local forced under a specified algorithm.

[0002] There is a known method for stamping a box from a parent sheet on a single-action press (RF invention patent No. 2527820, publ. on 10.09.2014, Bull. No. 25), including the placement of a workpiece in a die for extension, pressing of the workpiece flange by the hold-down's working surface to the pressing surface of the counter die and extension of the box by pulling the workpiece flange into the clearance between the punch and counter die, forming a box wall using the punch and the counter die, whose outlines in plan view correspond to the box wall outline in plan view with account of the wall thickness, after extension there are one or several holes in the box bottom, characterized in that a sheet workpiece is made preliminarily with holes punched in the areas corresponding to the unsafe cross-sections during extension and located opposite to the angular chamfers of the minimum curvature radius of the box wall in plan view.The disadvantage of this method is the low quality of produced parts, because the box part has technological holes.Moreover, there is a known method for multi-operation extension of a box part from a parent sheet on single-action presses or a multiple-point automatic press (RF invention patent No. 2545863, publ. on 27.12.2014, Bull. No. 36). The dies for implementation of each operation in this extension method comprise the following main working parts: punch, counter die and hold-down. The punch is fastened on the die's fixed lower plate, and the counter die - on the movable upper plate. Inside the counter die there is an ejector of stamped semi-finished product, acting from a pusher by means of a die or press device. The hold down rests via the pushers onto the press bed or the die buffer, which provides the required force for pressing of the parent sheet flange and pushing-in of the inclined wall of the previous semi-finished product into the counter die for extension of the subsequent semi-finished product.A disadvantage of this method is the limited technological capabilities related to need for new jigging in each machining step, which also needs replacement during change of the manufactured part. In the prior art a device is known for adjustment of bed load and a press machine, containing a device for adjustment of bed load (RF invention patent No. 2401742, publ. on 10.04.2010, Bull. No. 10), containing a bed under the press slide. The adjustment device comprises a hydraulic cylinder, forming the die bed, a hydraulic control valve connected with this cylinder, a hydraulic source, an opening speed adjustment unit, a unit for determination of die bed lowering speed, a signal correction unit.The shortcomings of the described device include restricted technological capabilities, related to the fact that local forces of the hold-down in its different points are constant but may vary in time. Moreover, special equipment is required for control of local forces.The said methods are implemented using the standard elements, namely mechanical and gas springs, arranged in the die between the hold-down and the die block part (lower or upper plate), and/or damping devices built into the press.There is a known design of a damping device with a pneumatic spring (RF useful model patent No. 81541, publ. on 20.03.2009, Bull. No. 8), comprising a reservoir containing a stem with a piston, the following successively installed on the stem: guide with cover, first sealing element, back-up ring, second sealing element which together with the stem form a cavity with lubricating fluid. The stem guide and the back-up ring have radial channels connected with the cavity; the first channel serves as an oil supply line, the second serves for air discharge from the cavity and has a return valve, additionally, the pneumatic spring comprises a unit for cavity filling with lubricating fluid.The disadvantage of this design is the constancy of the algorithm for control of local force transfer upon press impact on the hold-down, related to the fact that local forces are transferred according to linear law depending on cylinder stem motion.The suggested technical object is aimed at increasing the technological capabilities of the sheet stamping process and accuracy of manufactured parts, as well as the possibility of its use on universal equipment.The technical effect is achieved by the installation of a differentiated hold-down device into the die; the device ensures the following during workpiece forming: adjustment of metal flow and movement from the periphery into the deformation zone by way of local force control. A differentiated hold-down device, characterized in that the hold-down is made of sectors, fastened on a plate, and each hold-down sector is equipped with a hydraulic device for force transfer under a specified algorithm. The differentiated hold-down device comprises a hydraulic device for force transfer under a specified algorithm, comprises a housing, a stem with a piston, the housing comprises rings with an internal surface of variable cross-section, which together with the piston's peripheral surface form a clearance that may change during the piston movement in relation to the housing. Additionally, the differentiated hold-down device may comprise a hydraulic device for force transfer under a specified algorithm, which consists of a housing, a stem with piston, the stem is hollow and has radial holes, while the piston is provided with a movable ring configured to close the piston hole, the housing comprises an axle of variable cross-section, one end whereof is made in the form of a piston placed in the stem cavity, wherein the movable ring together with the axle of variable cross-section form a clearance that may change during movement of the hollow stem with the piston and ring in relation to the axle.The essence of the declared technical solution is shown in figures. Fig.1 shows the die of sheet stamping with a differentiated hold-down device; Fig.2 - the die of sheet stamping with a differentiated hold-down device, section A-A; Fig.3 - the hydraulic device for force transfer under a specified algorithm accord-

ing to the first embodiment; Fig.4 - the hydraulic device for force transfer under a specified algorithm according to the second embodiment; Fig.5 - the die of sheet stamping with a differentiated hold-down device at the beginning of the shaping process; Fig.6-the hydraulic device for force transfer under a specified algorithm according to the first embodiment at the beginning of the shaping process; Fig.7 - the hydraulic device for force transfer under a specified algorithm according to the second embodiment at the beginning of the shaping process; Fig.8 - the die of sheet stamping with a differentiated hold-down device in the shaping process; Fig.9 - the hydraulic device for force transfer under a specified algorithm according to the first embodiment in the shaping process; Fig.10 - the hydraulic device for force transfer under a specified algorithm according to the second embodiment in the shaping process; Fig.11 - the die of sheet stamping with a differentiated hold-down device at the end of the shaping process; Fig.12 - the hydraulic device for force transfer under a specified algorithm according to the first embodiment at the end of the shaping process; Fig.13 - the hydraulic device for force transfer under a specified algorithm according to the second embodiment at the end of the shaping process; Fig.14 - the change of force value at δ = 0.03 mm; Fig.15 - the change of force value at δ = 0.04 mm; Fig.16 - the change of force value at δ = 0.05 mm; Fig.17 - the change of force value at δ = 0.25 mm; Fig.18 - the graphical dependence of change in local forces on clearance of the hydraulic device for force transfer under a specified algorithm, built according to the first embodiment; Fig.19 -the graphical dependence of change in local forces on clearance of the hydraulic device for force transfer under a specified algorithm, built according to the second embodiment.The claimed method for control of local forces in the die of sheet stamping is implemented using the following components: upper plate 1 and lower plate 2, whereon punch 3 and counter die 4 are rigidly installed. Additionally, a differentiated hold-down device 5 is installed on upper plate 1; this device comprises several hydraulic devices 6 for force transfer under a specified algorithm and hold-down 7. Hydraulic device 6 for force transfer under a specified algorithm comprises housing 8, stem 9, one end whereof is fastened on upper plate 1, while the other is in the form of piston 10. Inside housing 8 there are rings 11 with internal surface of variable cross-section 12. Clearance δ is provided between the peripheral surface of piston 10 and the internal surface of variable cross-section 12 of rings 11. Cover 13 is installed on the housing butt surface. Inside housing 8 there is spring ring 14, restricting the travel of air piston 15 with sealing rings 16, which is installed between housing 8 and stem 9. Spring 17 is installed between air piston 15 and cover 13. It is possible to manufacture device 6 for load transfer under a specified algorithm, which comprises hollow stem 18 with radial holes 19, capable of moving along the axle of variable cross-section 20, one end whereof is made in the form of piston 21 with seals 22, while the other end is fixed in housing 8 by means of threaded joint 23. Stem 18 has piston 24 with holes 25 along its perimeter and sealing rings 26. Ring 27 is installed on one of the butts of piston 24. Ring 27 together with holes 25 and spring ring 28, installed in piston 24, forms a return valve. Besides, ring 27 together with axle 20 forms clearance Δ. Hold-down 7 consists of separate sectors 29, rigidly fastened on common steel plate 30, to which housings 8 of hydraulic devices 6 for force transfer under a specified algorithm are fastened. Wherein, housings 8 are located opposite the corresponding sectors 29.Let us consider the application of the method to control local forces in dies of sheet stamping and the operation of the differentiated hold-down device according to the example of shaping of a box-section part. The standard sheet stamping technology provides for the use of gas or mechanical springs, wherein local forces are transferred to the rigid hold-down. Value of hold-down force is selected on the basis of assurance of metal flow in places of dislocation of the maximum internal stresses at the initial shaping moment and applies to the entire surface of hold-down contact with the part. As the springs are compressed according to the slide, the force increases and does not depend on the value required for the optimal shaping process. Wherein defects may occur such as excessive thinning up to rupture, or thickening up to wrinkling.In the suggested method, local forces in the shaping process are controlled as follows. At the initial stage a calculation is performed in order to determine the optimal local forces of the hold-down in different workpiece areas and in different moments of the shaping process. The obtained data is used to determine the necessary quantity and mutual location of sectors for hold-down 29, which are fastened on elastic plate 30, thus forming hold-down 7. Devices 6 for force transfer under a specified algorithm are fastened to each sector 29. Hold-down 7 and devices 6 form differentiated hold-down device 5 that allows for control of local forces in the die. Stamping is performed by moving upper plate 1 together with punch 3 and differentiated hold-down device 5 in relation to lower plate 2, whereon counter die 4 is fastened. At the initial time moment, a differentiated hold-down device 5 squeezes the workpiece with the design forces provided by devices 6 for force transfer under a specified algorithm. Wherein the force value on each of sectors 29 is different and corresponds to the optimal value for the shaping process at the given time moment and in the given zone of hold-down 7. Change of force for each device 6 for force transfer under a specified algorithm is determined according to the value of clearances δ or Δ. In the next time moment the punch comes to the workpiece surface and starts deforming it. Wherein changes of local forces in the sectors of hold-down 29 are necessary to ensure the optimal shaping process. Further deforming of the workpiece also causes redistribution of local forces in the sectors of hold-down 29, which continues until completion of the shaping process and is ensured through control by device 6.Two embodiments are suggested for implemen-

tation of hydraulic device 6 for force transfer under a specified algorithm and, accordingly, two embodiments of operation of the differentiated hold-down device. Both embodiments are described below.Operation of hydraulic device 6 for force transfer under a specified algorithm according to the first embodiment is as follows. At the initial moment, stem 9 and piston 10 are in the upper position, wherein pressure in the cavity under the piston is equal to atmospheric pressure. When stem 9 moves downwards under the action of die's upper plate 1, fastened on the press slide, pressure in the cavity under the stem piston increases. Pressure value in this case is determined by motion speed of stem 9 and clearance δ between the inner surface of variable cross-section 12 of rings 11 and the peripheral surface of piston 10. Motion speed of stem 9 depends on motion speed of the press slide and may vary up to zero. Rings 11, installed inside housing 8, are made with internal surfaces of variable cross-section 12. When the peripheral surface of piston 10 passes in relation to rings 11, clearance δ between them changes. Change of clearance δ allows for adjusting the speed of working fluid overflow from the cavity under piston 10 into the cavity above the piston and, respectively, controls the pressure in the cavity under piston 10, which via housing 8 is transferred to the sectors of hold-down 29. Shape of the internal surfaces of rings 11 is determined by calculation so as to ensure the optimal shaping process for the given hold-down sector and, together with the peripheral surface of piston 10, assigns an algorithm for control of force transfer from the press slide via the upper plate to a specific sector of hold-down 29. The number of rings 11 depends on control algorithm complexity. The working fluid in the cavity above the piston moves air piston 15, by compressing spring 17. Shape of the internal surfaces of rings 11 is determined by calculation so as to ensure the optimal shaping process for the given hold-down sector and, together with the peripheral surface of piston 10, assigns an algorithm for control of force transfer from the press slide via the upper plate to a specific sector of hold-down 29. When stem 9 moves backwards, the working fluid above the cavity of piston 10 under the weight of housing 8 and hold-down 7, as well as the accumulated energy of spring 17 flows from the cavity above the piston into the cavity under the piston. Ring 14 is configured to restrict the travel of air piston 15. Sealing rings 16 prevent the ingress of working fluid into the air chamber formed by air piston 15, cover 13 and internal walls of housing 8.Operation of hydraulic device 6 for force transfer under a specified algorithm according to the second embodiment is as follows. At the initial moment, hollow stem 18 and piston 24 are in the upper position, wherein pressure in the cavity under the piston is equal to atmospheric pressure. When stem 18 moves downwards under the action of die's upper plate 1, fastened on the press slide, pressure in the cavity under the stem piston increases and presses ring 27 to the butt surface of hollow piston 18, which closes holes 25. The hole of ring 27 and the outer surface of axle 20 form variable clearance Δ, through which the working fluid flows over to the cavity formed by axle 20 and the internal surface of hollow stem 18. Then the working fluid flows through radial holes 19 into the cavity above piston 24. The value of pressure under piston 24 in this case is determined according to the motion speed of stem 18 and clearance Δ between the hole of ring 27 and the outer surface of axle 20. Motion speed of stem 18 depends on motion speed of the press slide and may vary up to zero. Axle 20, having a variable cross-section, is fastened to the bottom of housing 8 by thread 23. When piston 24 with ring 27 moves in relation to axle 20, the value of clearance Δ changes. Change of clearance Δ allows for adjusting the speed of working fluid overflow from the cavity under piston 24 into the cavity above the piston and, respectively, controls the pressure in the cavity under piston 24, which via housing 8 is transferred to the sectors of hold-down 29. Shape of the surface of axle 20 is determined by calculation so as to ensure the optimal shaping process for the given sector of hold-down 29 and, together with the hole of ring 29, assigns an algorithm for control of force transfer from the press slide via upper plate 1 to a specific sector of hold-down 29. Sealing rings 26, arranged on piston 24, prevent working fluid ingress into the cavity above the piston, bypassing clearance Δ. The working fluid in the cavity above the piston moves air piston 15, by compressing spring 17. When stem 18 moves backwards, the working fluid above the cavity of piston 10 under the weight of housing 8 and hold-down 7, as well as the accumulated energy of spring 17 moves ring 27 up to the extreme position, limited by ring 28, and flows through holes 25 from the cavity above the piston into the cavity under the piston. Ring 14 is configured to restrict the travel of air piston 15. Sealing rings 16 prevent the ingress of working fluid into the air chamber formed by air piston 15, cover 13 and internal walls of housing 8. Sealing rings 22 prevent working fluid ingress into the intracavity of stem 18.The experimental results have showed a considerable change in local forces upon clearance change. Several experiments have been carried out with the following input values:hydraulic device 6 for force transfer under a specified algorithm built according to the first embodiment;diameter of piston 10 is equal to 49 mm;clearance values 0.03, 0.04, 0.05 and 0.25 mm;viscosity of working fluid ISO VG-10 (Mobil Velocite 6);press model K3732.With the clearance of δ = 0.03 mm, the force value was 23.4 tons, δ = 0.04 mm - 2.08 tons, δ = 0.05 mm - 1.28 tons and δ = 0.25 mm - 0.33 tons.The results of the experiment using hydraulic device 6 for force transfer under a specified algorithm, built according to the second embodiment with the diameter of internal hole in ring 27 equal to 5 mm, are as follows: with clearance Δ = 0.3 mm the force was 23.4 tons, Δ = 0.38 mm - 2.08 tons, Δ = 0.47 mm - 1.28 tons and Δ = 2.04 mm - 0.33 tons.Fig. 18 and Fig. 19 show graphical dependences of change in local forces on clearance of hydraulic device 6 for force transfer under a specified algorithm, built according to

the first and second embodiments respectively. Analysis of the graphical dependences showed that the rational use region for the device, manufactured according to the first embodiment, is in the force range from 0.5 tons to 2.5 tons, and for the device according to the second embodiment - from 2 tons to 11 tons. Thus, we may conclude that these device may complement the operation of each other and be used in the differentiated hold-down device depending on the specified conditions of the shaping process.The positive result from the suggested technical solution is as follows. Control of local forces of workpiece pressing to the counter die positively affects the shaping process, extends the technological capabilities, allowing for manufacturing parts of hard-to-deform materials, as well as increases the accuracy of part manufacture. Compactness of the differentiated hold-down device and the possibility to use a relatively simple and reliable control member, that can be made for the given part, allows for its installation in the standard dies used in universal equipment.

Claims

1. A method of controlling local forces in dies of sheet stamping where said die comprises an upper plate and a lower plate, a counter die, a punch and a hold-down made of sectors, wherein said method comprises: installing a differentiated hold-down device in said die; wherein the device is configured to ensure an adjustment of metal flow and movement of metal from periphery into the deformation zone during workpiece forming by way of local force control on each of the hold-down sectors under a specified algorithm.

2. A differentiated hold-down device, wherein the hold-down is made of sectors fastened on a plate, and each hold-down sector is equipped with a hydraulic device for force transfer under a specified algorithm.

3. The differentiated hold-down device according to claim 2, wherein the hydraulic device for force transfer under a specified algorithm comprises a housing and a stem with a piston, said housing comprises rings with an internal surface of variable cross-section and is configured to form a clearance together with the piston's peripheral surface, wherein said clearance is changing during the piston movement in relation to the housing.

4. The differentiated hold-down device according to claim 2, wherein the hydraulic device for force transfer under a specified algorithm comprises a housing and a stem with piston, wherein said stem is hollow and has radial holes; the piston is provided with a movable ring capable of closing the piston holes; the housing comprises an axle of a variable cross-section, with one end of said axle made in the form of a piston placed in the stem cavity; and the movable ring together with the axle of a variable cross-section form a clearance that is changing during movement of the hollow stem with the piston and ring in relation to the axle.

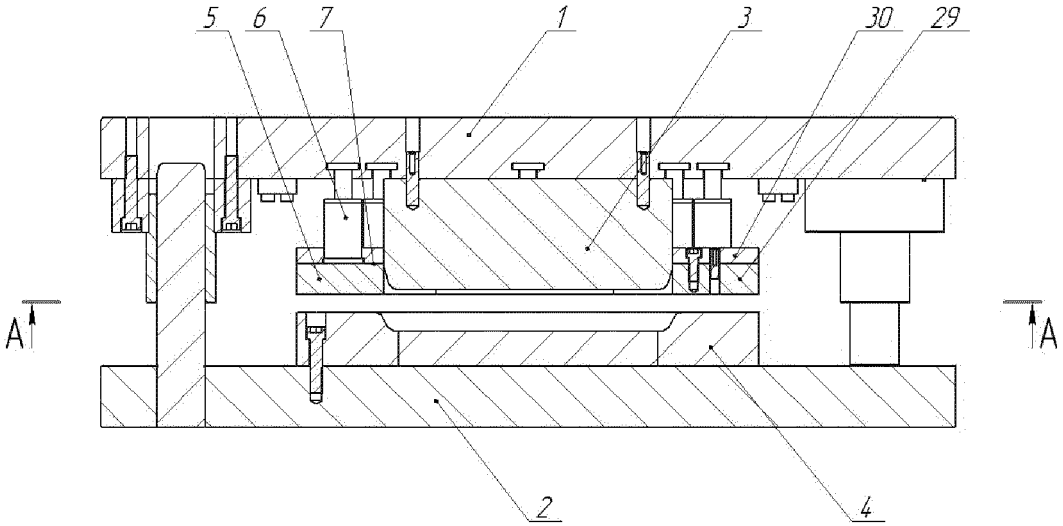


Fig.1

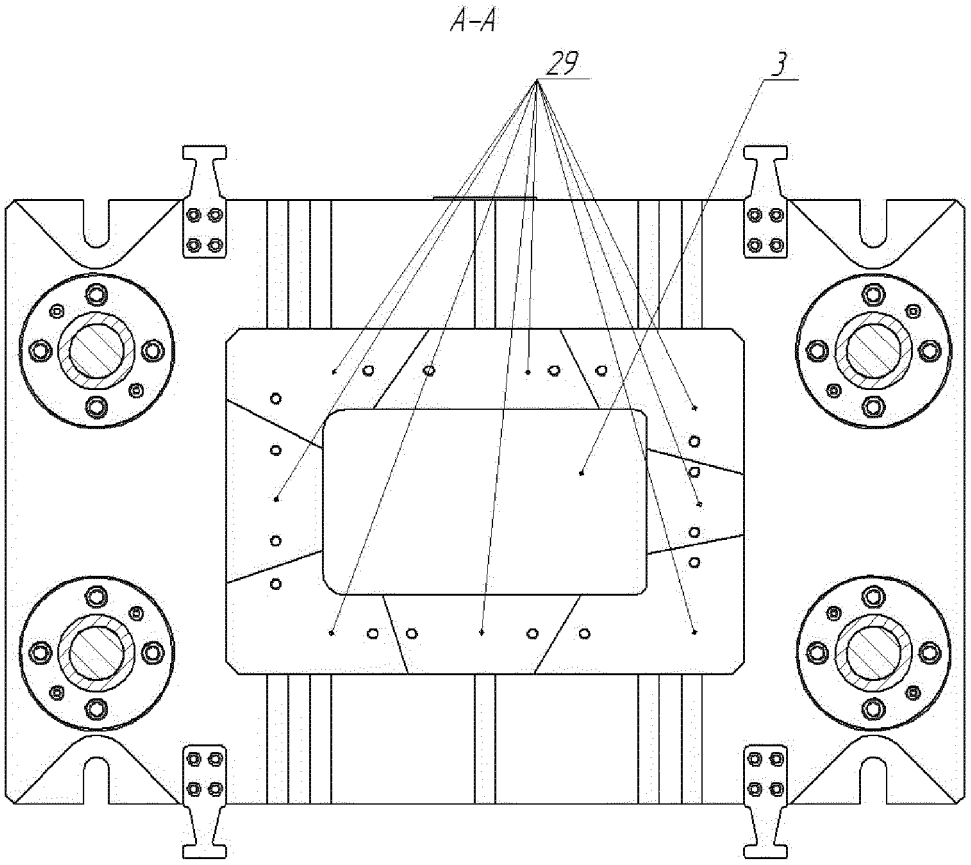
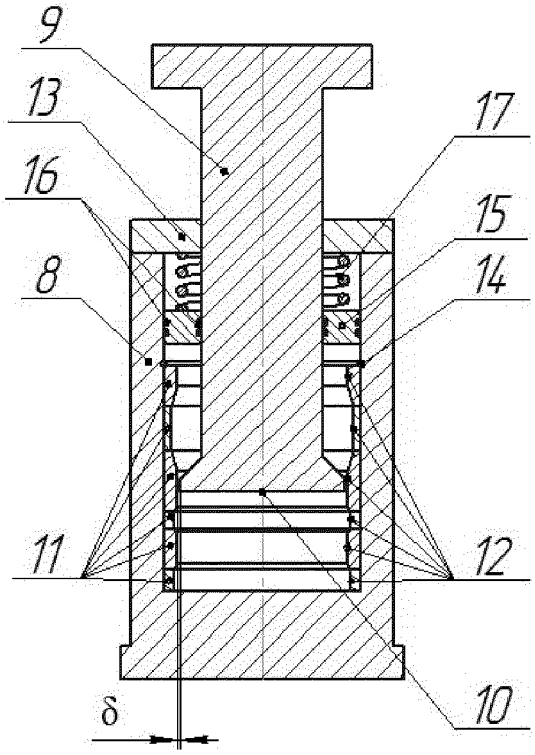


Fig.2


9
13
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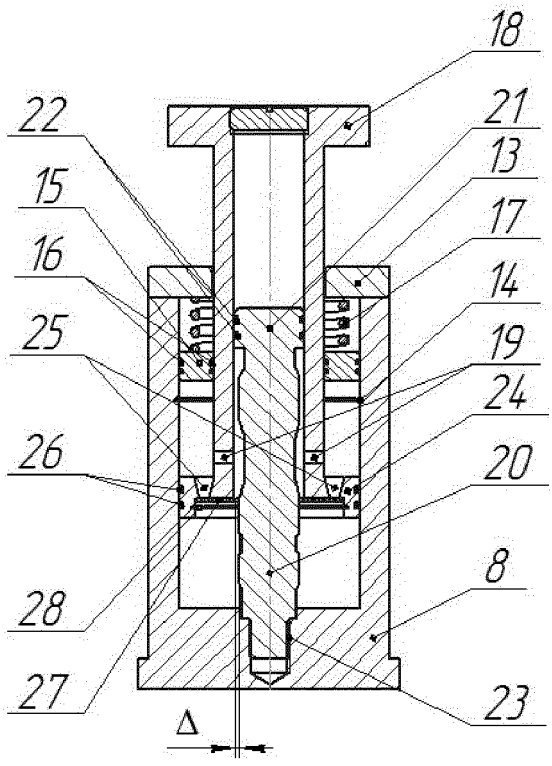
δ

Fig.3


18
22
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25
14
19
24
26
20
8
28
27
23
Δ

Fig.4

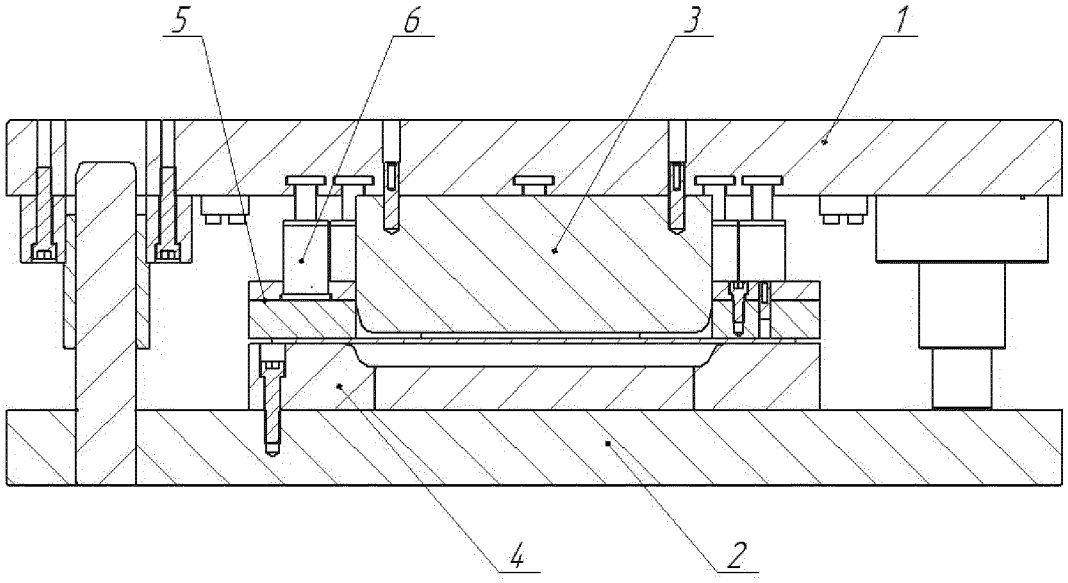


Fig.5

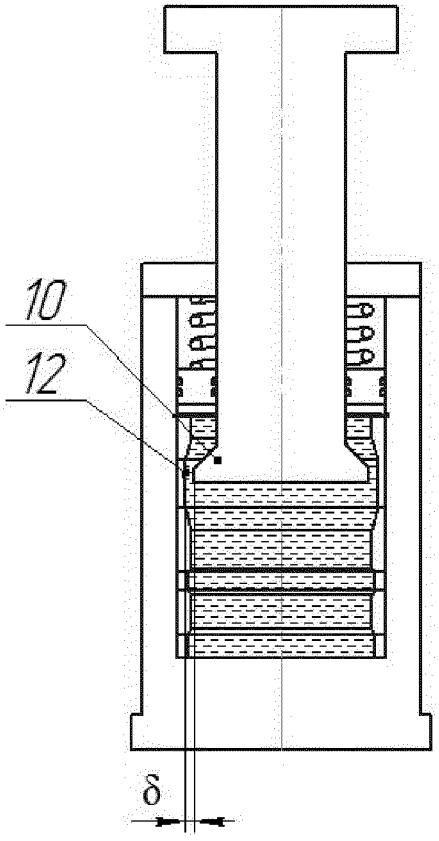


Fig.6

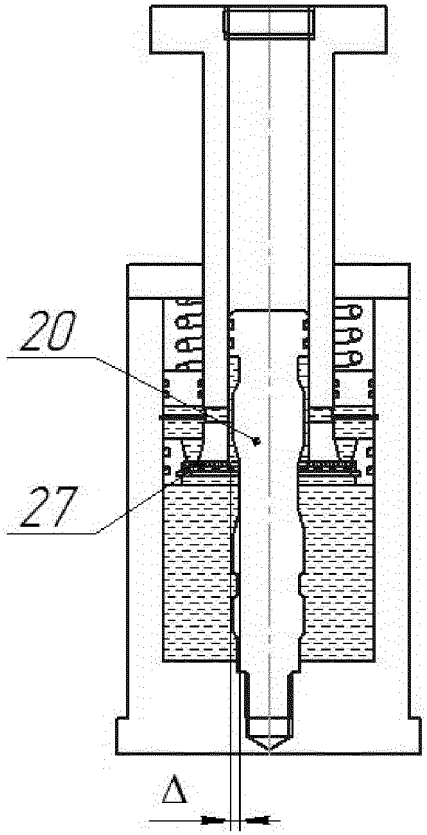


Fig.7

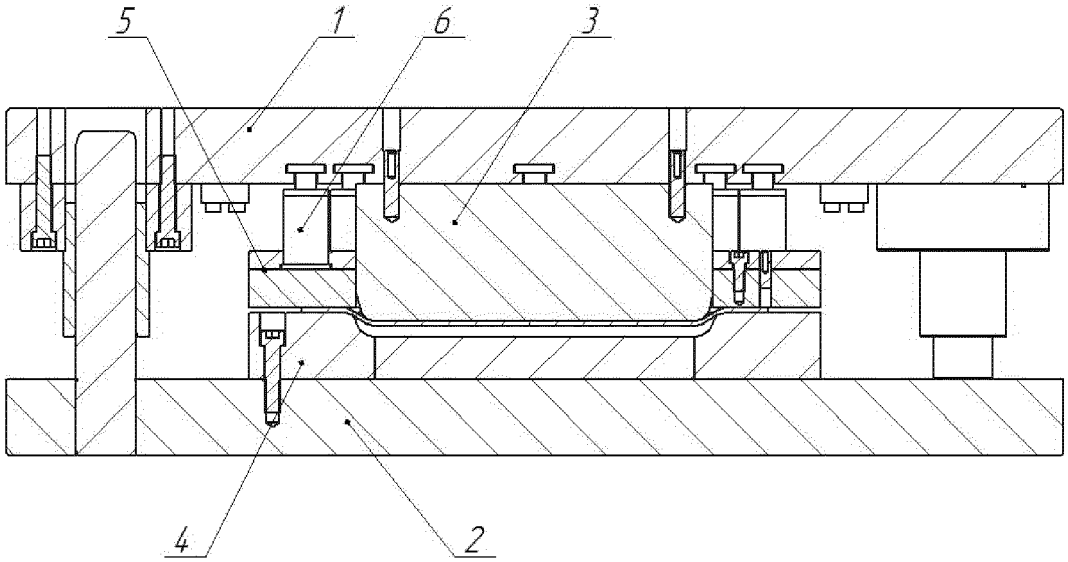


Fig.8

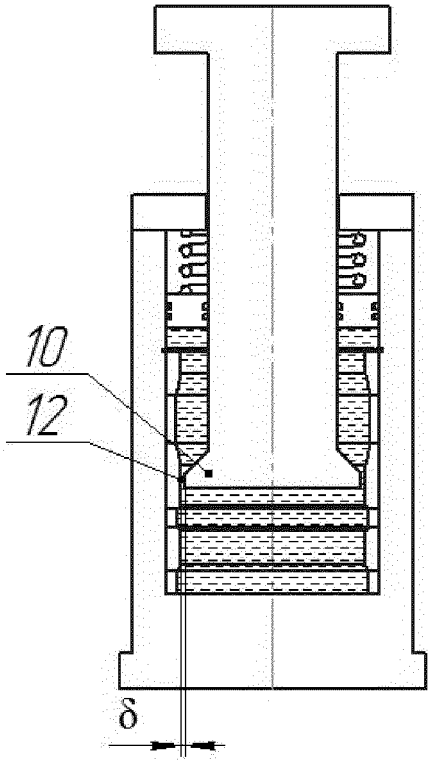


Fig.9

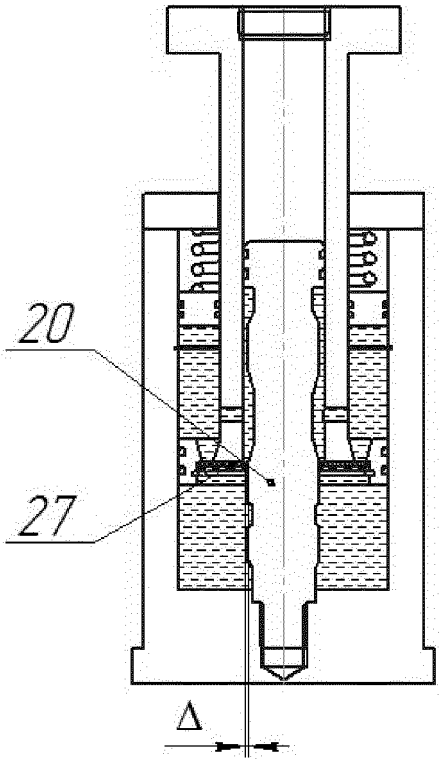


Fig.10

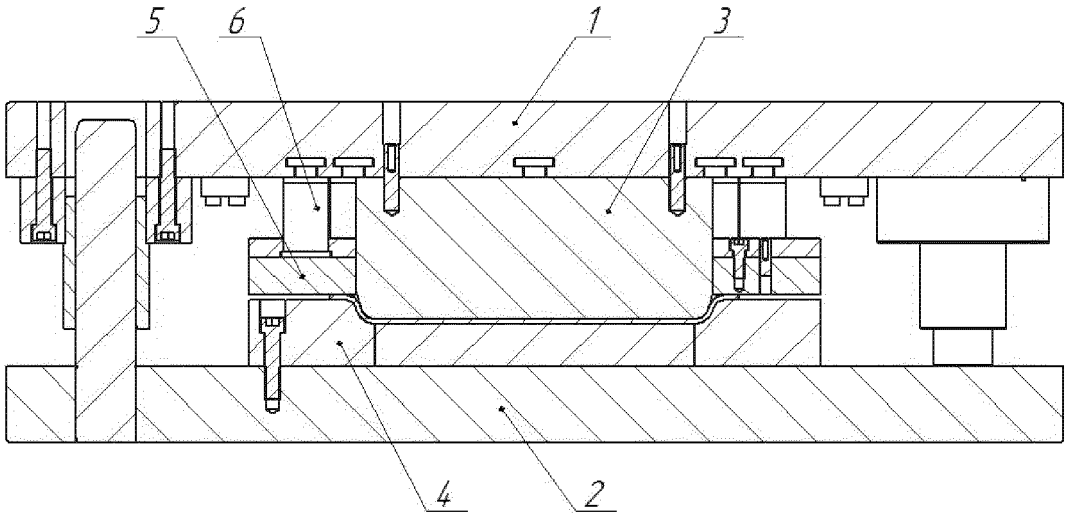


Fig.11

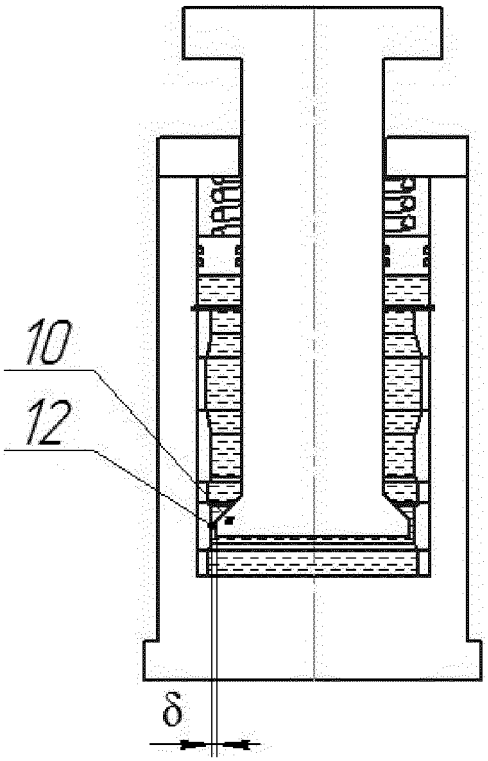


Fig.12

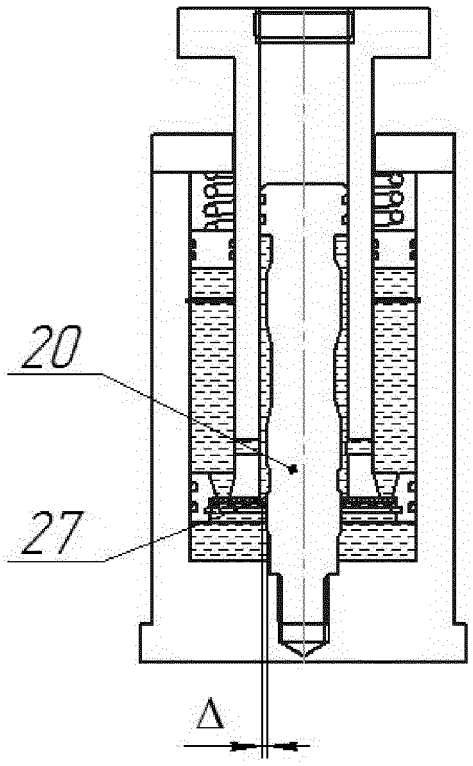
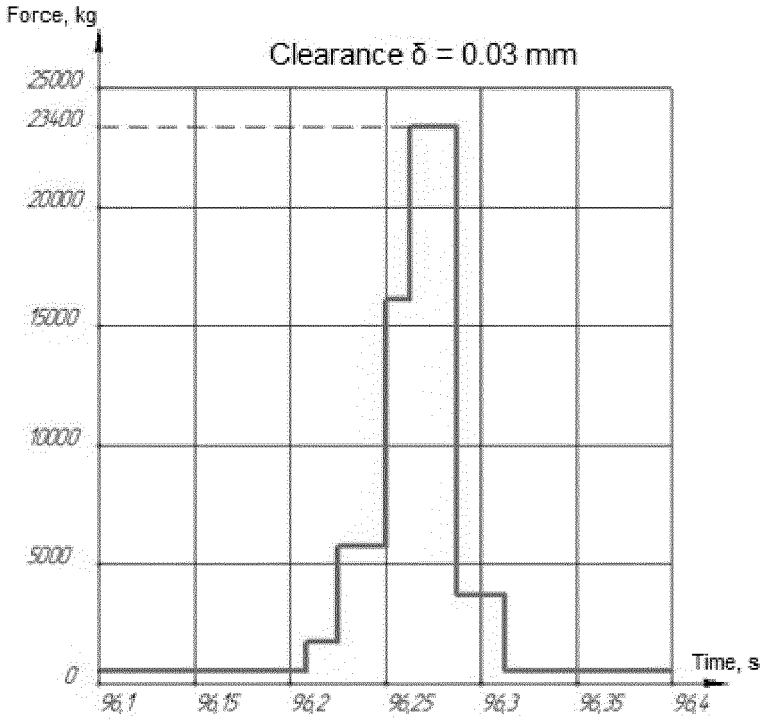

20
27
Δ

Fig.13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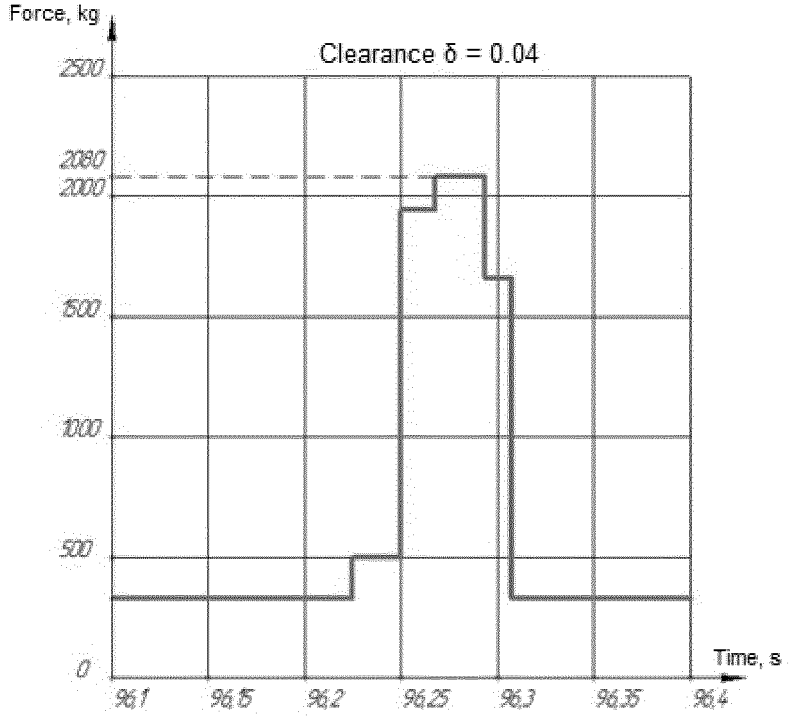
23400
20000
15000
10000
5000
0
Time, s
96,1
96,15
96,2
96,25
96,3
96,35
96,4

Fig.14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2080
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1000
500
0
Time, s
96,1
96,15
96,2
96,25
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96,35
96,4

Fig.15

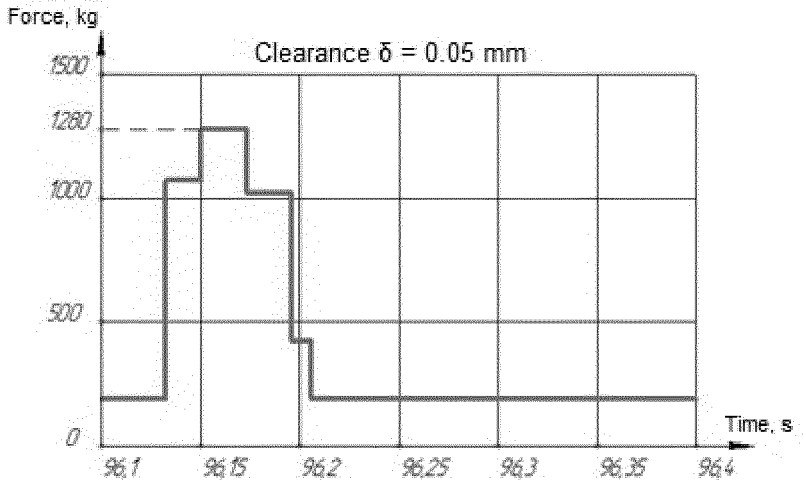
Force, kg
Clearance δ = 0.05 mm
1500
1280
1000
500
0
Time, s
96,1
96,15
96,2
96,25
96,3
96,35
96,4

Fig.16

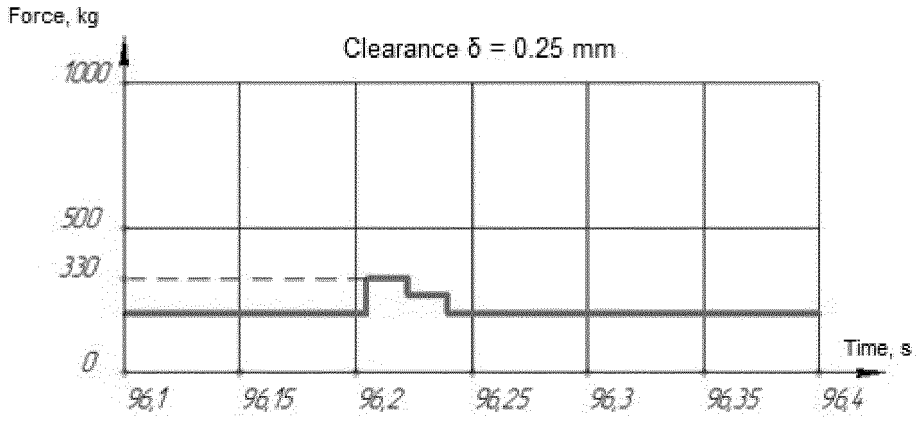
Force, kg
Clearance δ = 0.25 mm
1000
500
330
0
Time, s
96,1
96,15
96,2
96,25
96,3
96,35
96,4

Fig.17

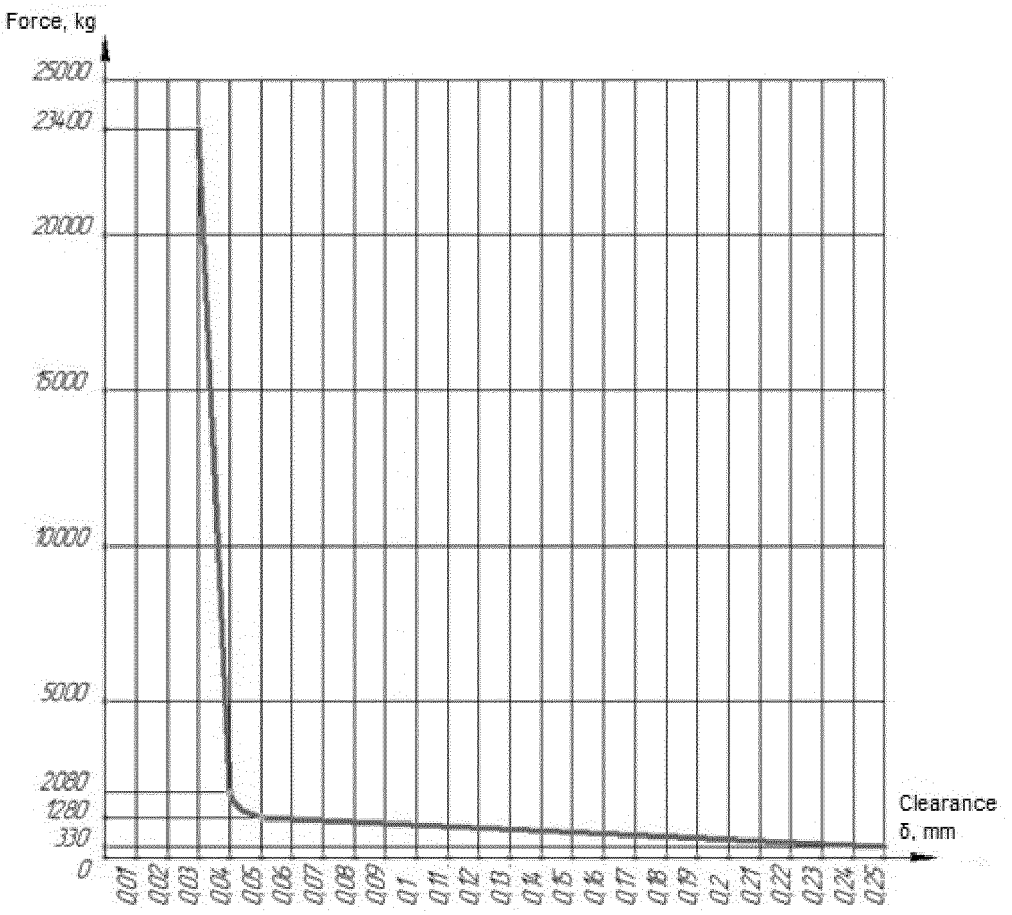
Force, kg
25000
23400
20000
15000
10000
5000
2080
1280
330
0
Clearance
δ, mm
0,01
0,02
0,03
0,04
0,05
0,06
0,07
0,08
0,09
0,1
0,11
0,12
0,13
0,14
0,15
0,16
0,17
0,18
0,19
0,2
0,21
0,22
0,23
0,24
0,25

Fig.18

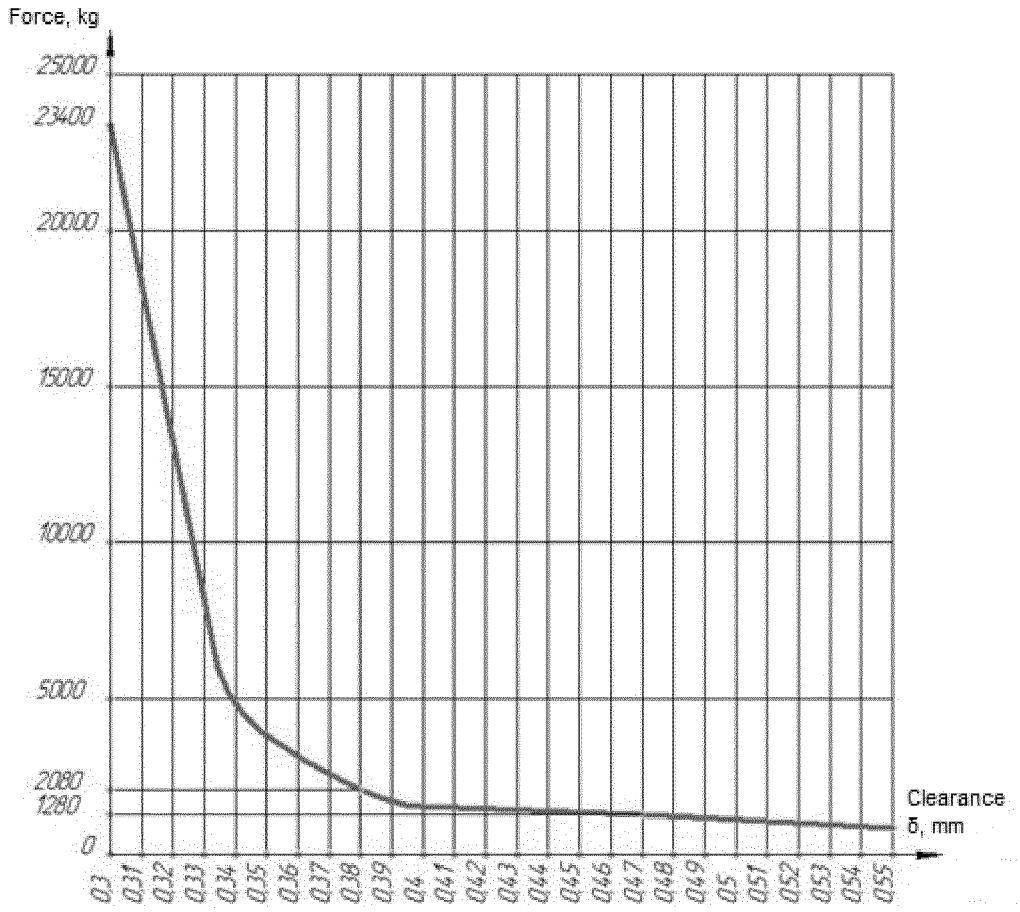
Force, kg
25000
23400
20000
15000
10000
5000
2080
1280
0
Clearance
δ, mm
03
031
032
033
034
035
036
037
038
039
04
041
042
043
044
045
046
047
048
049
05
051
052
053
054
055

Fig.19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 2017/000632

A. CLASSIFICATION OF SUBJECT MATTER
B21D 22/22 (2006.01); B21D 24/04 (2006.01); B21D 24/14 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21D 22/00, 22/20, 22/22, 24/00, 24/04, 24/08, 24/10, 24/14, B25D 9/00, B23B 31/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SU 524584 A (MOSKOVSKY AVIATSIONNY TEKHNOLOGICHESKY INSTITUT IMENI K.E. TSIOLKOVSKOGO) 15.08.1976, column 1, line 15 – column 2, line 25, the claims, fig.1	1
X	SU 776713 A (SIZOV E.S. et al.) 07.11.1980, column 1, lines 21-23, column 2, line 16 – column 4, line 22, fig.1-4	2
Y		3-4
Y	RU 2580112 C1 (OBSCHESTVO S OGRANICHENNOI OTVETSTVENNOSTJU «UKRAINSKAYA IMPULSNAYA INDUSTRIYA») 10.04.2016, the claims, fig.1	3
Y	SU 1811997 A1 (MOSKOVSKOE STANKOSTROITELNOE PROIZVODSTVENNOE OBEDINENIE «KRASNY PROLETARY») 30.04.1993, the claims, fig.1	4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 April 2018 (03.04.2018)	26 April 2018 (26.04.2018)
Name and mailing address of the ISA/ RU	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 2017/000632

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2201830 C2 (OTKRYTOE AKTSIONERNOE OBSCHESTVO «GAZ») 10.04.2003	1-4
A	SU 1324724 A1 (ERSHOV V.I. et al.) 23.07.1987	1-4
A	WO 1999/020411 A1 (COSMA INTERNATIONAL INC) 29.04.1999	1-4

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2527820 A **[0002]**
- WO 2545863 A **[0002]**
- WO 2401742 A **[0002]**
- WO 81541 A **[0002]**